MATH 5340 – Comp Method II

Homework #2

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1 Step 1: 1D

1.1 Instructions

Basic command to run 1D code is:

```
make 1D
```

Or you can compile it first by `make`, and then run the executable `./theta1D` .

Some parameters can be changed using Makefile macros:

```
make -B LENGTH=3.0 HEIGHT=0.5 1D
```

Adjustable parameters during compile time includes:

Name	**Example**	**Description**
Data	`DATA=XIUKUN`	*Decide whose initial and boundary conditions to be used. Options include: `XIUKUN`, `GEETA` and `MALLORY`.*
Length	`LENGTH=3.0`	*Domain length in inch.*
Time	`TIME=70`	*Total time computed, in minute.*
Alpha	`ALPHA=.2`	*Thermal Diffusivity in inch/min.*

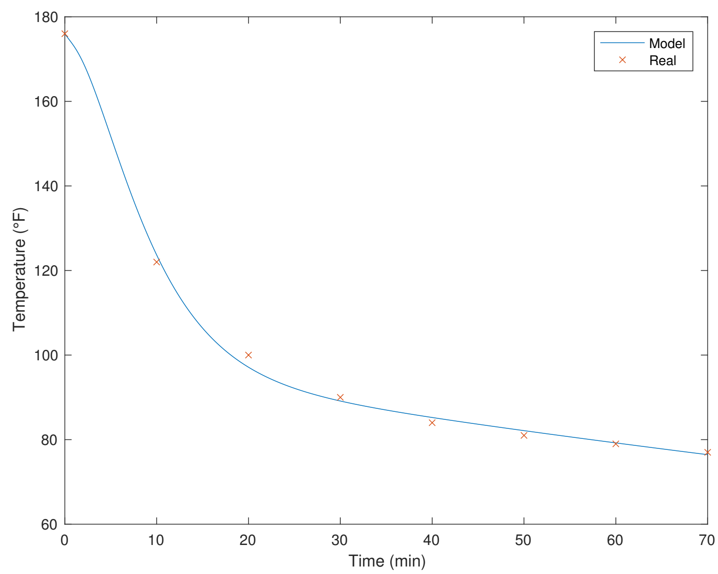
dx (inch), dt (minute) and θ are required as input in runtime. If input is illegal, you need to input again. If θ is `-1`, then the special case $\theta = \frac{1}{2} - \frac{(\Delta x)^2}{12\Delta t}$ will be applied.

1.2 Result

The initial conditions are acquired using quadratic interpolation with central and exterior temperature data, assuming that both end have the same temperature. The boundary conditions are acquired using exponential regression with boundary data collected.

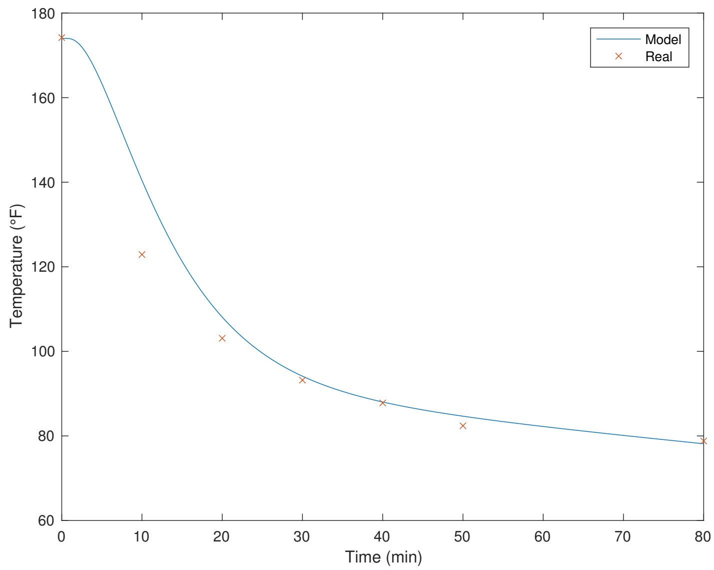
The output includes two files: `theta1D.txt` and `theta1D.bin`. The text file contains information of the model, which is used in visualizing the data. The binary file contains output data in binary format. Please see Section 3 about how to visualize resulting data.

Figure 1 are the comparison between numerical central temperatures and central temperatures collected from homework 1. The settings for numerical solution are $dx = .1, dt = .01, \theta = -1$, and the thermal diffusivity $\alpha = .2$.

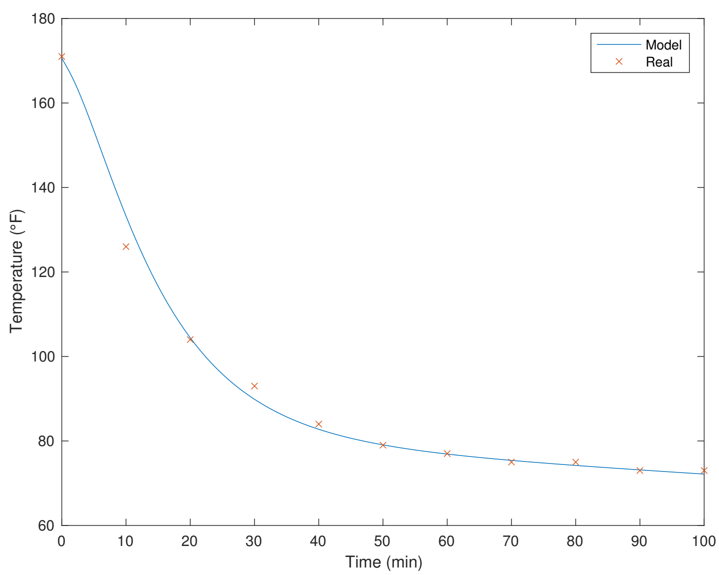


(a) Xiukun's Data

Figure 1: Data Comparison



(b) Geeta's Data



(c) Mallory's Data

Figure 1: Data Comparison (cont.)

There is a video file named `theta1D.mp4` showing the cooling process in 1D with Mallory's initial condition and boundary condition.

1.3 Performance

The following elapsed times are recorded using GNU *time*. The elapsed real time in second is presented. $\theta = 1$ is applied. And $\mathtt{nt} = 70000$ for all tests.

nx	300	600	1200	2400	4800	9600
real	0.80	1.43	2.68	5.32	10.57	21.19

Table 1: Elapsed time of 1D code

2 Step 2: 2D

2.1 Instructions

Basic command to run 1D code is:

```
make 2D
```

Or you can compile it first by `make`, and then run the executable `./theta2D`.

Some parameters can be changed using Makefile macros:

```
make -B LENGTH=3.0 HEIGHT=0.5 2D
```

Adjustable parameters during compile time includes:

dy (inch), dx (inch), dt (minute) and θ are required as input in runtime. If input is illegal, you need to input again.

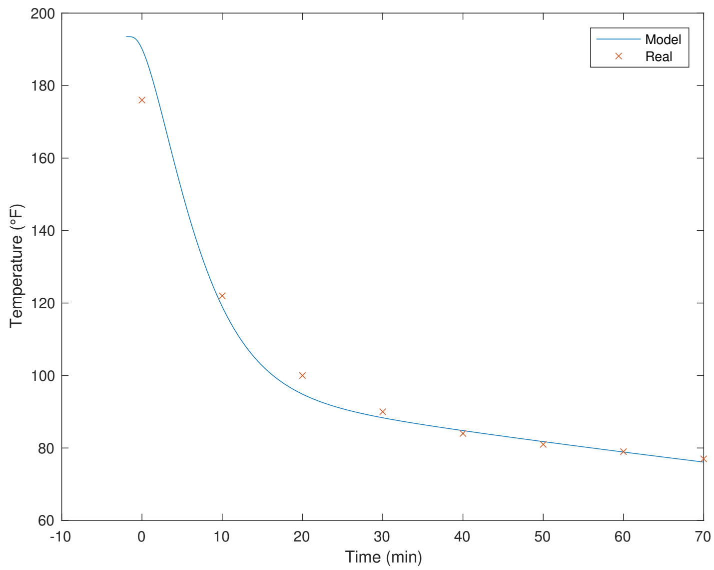
Name	Example	Description
Data	`DATA=XIUKUN`	*Decide whose initial and boundary conditions to be used. Options include: `XIUKUN`, `GEETA` and `MALLORY`.*
Length	`LENGTH=3.0`	*Domain length in inch.*
Height	`HEIGHT=.5`	*Domain height in inch.*
Time	`TIME=70`	*Total time computed, in minute.*
Alpha	`ALPHA=.2`	*Thermal Diffusivity in inch/min.*

2.2 Result

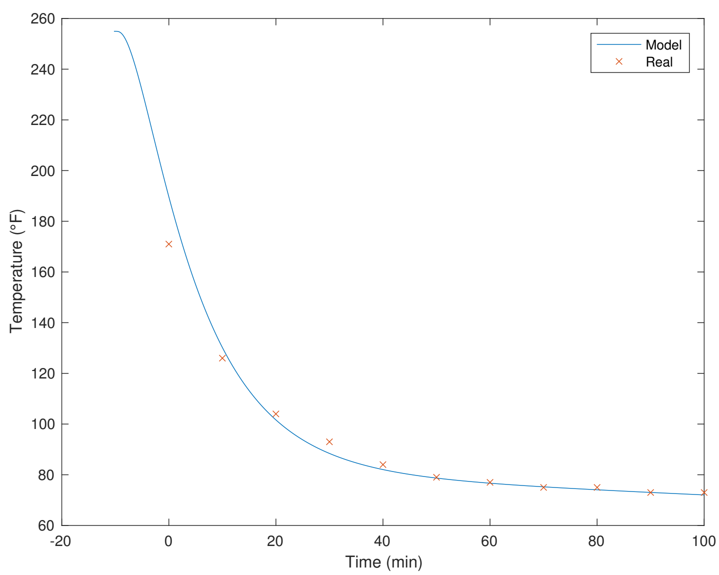
The boundary conditions are the same as in 1D (exponential interpolation). The initial conditions however are acquired using the assumption that there is a time point when the temperature is the same everywhere in the muffin. This time point is calculated by exponentially interpolate center temperature and find the time when the center temperature equals the exterior temperature. That time is set to be t_0 and the initial condition is just constant.

The output includes two files: `theta2D.txt` and `theta2D.bin`. The text file contains information of the model, which is used in visualizing the data. The binary file contains output data in binary format. Please see Section 3 about how to visualize resulting data.

Figure 2 are the comparison between numerical central temperatures and central temperatures collected from homework 1. The settings for numerical solution are $dx = .01, dy = .01, dt = .01, \theta = 1/2$, and the thermal diffusivity $\alpha = .2$.

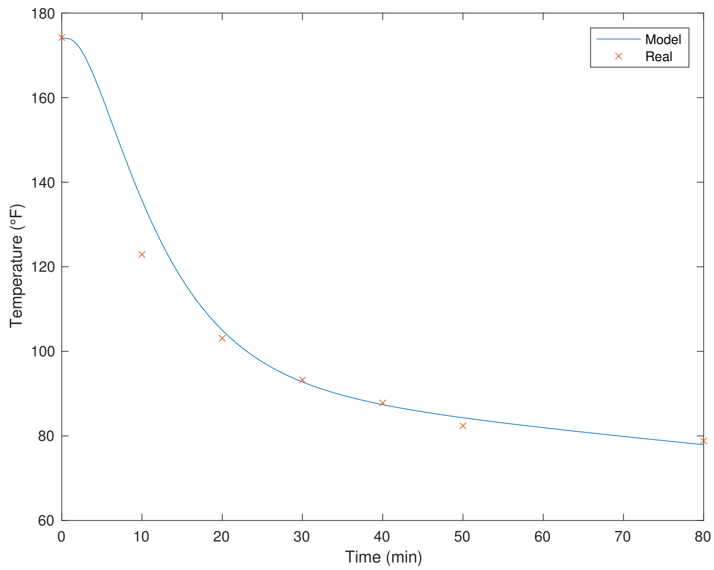


(a) Xiukun's Data



(b) Mallory's Data

Figure 2: Data Comparison



(c) Geeta's Data

Figure 2: Data Comparison (cont.)

There is a video file named `theta2D.mp4` showing the cooling process in 2D with Geeta's initial condition and boundary condition.

2.3 Performance

The following elapsed times are recorded using GNU *time*. The elapsed real time in second is presented. $\theta = 1$ is applied. And $nt = 8000$ for all tests.

$nx \times ny$	150×25	300×50	600×100	1200×200
real	0.82	2.61	10.13	48.04

Table 2: Elapsed time of 2D code

Visualization

In order to visualize the output, use the Matlab code `Heat_Visualize.m`. There are two parameters for this Matlab code:

`nD`: default 1, legal values are 1 or 2. This parameter specify which data (1D or 2D) you want to visualize.

`timestep`: default 0.1, legal values are any positive number. This parameter determines the time step for the movie.